WINTER WATER MASS TRANSFORMATION IN THE LABRADOR SEA

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LONG TERM GOALS

To further our understanding of the dynamics of open ocean convection, including evolution and interaction on different scales ranging from the mesoscale to the gyre scale.

OBJECTIVES

The two main objectives are (1) To determine where convection occurs in the environs of the Labrador Sea and identify what factors dictate this location, and (2) To quantify the broad-scale circulation in which the convection is embedded and reveal how this circulation influences the subsequent re-stratification.

APPROACH

A 47-day hydrographic cruise was recently completed during the winter convective period in the Labrador Sea (2 Feb–20 Mar, 1997 aboard R/V Knorr). This represented the initial fieldwork phase of the ONR Deep Convection Accelerated Research Initiative (ARI), which includes numerous other components such as numerical modeling and meteorology. The cruise incorporated a dual strategy to sample on the basin scale, while reacting to anomalous convective conditions with smaller scale measurements. The ship also served as a platform for launching a large suite of floats and drifters, most of which were part of the ARI fieldwork component.

ACCOMPLISHMENTS

Despite experiencing harsh Labrador Sea wintertime conditions for the entire cruise, the hydrographic program was a remarkable success, far exceeding all expectations. A total of 127 Conductivity-Temperature-Depth (CTD) stations were occupied (Figure 1).Both the along-basin section and the southern cross-basin section were repeats of the fall Hudson cruise (done in conjunction with the ARI), the latter being the first wintertime occupation of the World Ocean Circulation Experiment (WOCE) AR7W line. The station grid included five detailed boundary crossings. On the western side we were limited by the proximity of the ice-pack, hence these sections do not extend onto the shelf. On the eastern side, particularly on the second crossing, the biggest concern was icebergs. Despite having to divert our cruise track a couple of times we did two highly resolved sections across the West Greenland Current and Irminger Water.

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE	2. REPORT TYPE	3. DATES COVERED
30 SEP 1997		**00-00-1997 to 00-00-1997**

4. TITLE AND SUBTITLE	5a. CONTRACT NUMBER
Winter Water Mass Transformation in the Labrador Sea	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER
	5e. TASK NUMBER
	5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **Woods Hole Oceanographic Institution,Department of Physical Oceanography,Woods Hole,MA,02543**	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S)
	11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited

13. SUPPLEMENTARY NOTES

14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a REPORT	b ABSTRACT	c THIS PAGE			
unclassified	**unclassified**	**unclassified**	**Same as Report (SAR)**	**4**	

Late in the cruise we re-occupied the central section through the heart of the gyre (Figure 1), and performed a detailed "tow-yo" survey in a recently convected patch of water. Lagrangian floats/drifters were deployed throughout the cruise.

SCIENTIFIC RESULTS

The atmospheric forcing was surprisingly strong during our 34-day working period in the region, and, despite a mild December, deep convection occurred to 1500 m. At the conclusion of the cruise the CTD data set was near-final (except for adjustments from the post-cruise laboratory calibrations) and vertical sections of all properties were made for each section. There were some unexpected surprises encountered during the cruise. Among these were the rapid rate of mixed-layer deepening, the remarkably small-scale (few kilometer) variability encountered during active convection, and the fact that the deepest convection occurred close to the boundary. The repeat section will shed light on some of these phenomena. The 36-hour "tow-yo" survey (Figure 2), which measured the deepest mixed-layer of the experiment, shows the re-stratification process occurring via capping over of the surface waters. Note also the strong intrusions at depth (Figure 2b). The lateral view (Figure 2c) shows an adjacent region of less well-ventilated water interacting with the newly convected lens.

IMPACT FOR SCIENCE

The repeat section during active convection, the full three-dimensional view provided by the tow-yo, and the planned analysis of the entire CTD survey will shed light on the dynamics of convective processes in the Labrador Sea. This work will also help with the interpretation of the model results and other observational (Lagrangian and moored) data collected by other investigators. It is the aim to enable future models to parameterize in realistic fashion the important larger scale effects of deep-sea convection.

TRANSITIONS

The CTD and shipboard measurements will be used extensively by other investigators of the ARI. Already the data have been used to help guide the follow-up spring CTD survey of the Labrador Sea, as well as for calibration of floats to be launched on the 1998 winter cruise.

RELATED PROJECTS

The hydrographic cruise was part of the Deep Convection ARI, and served as a platform for numerous other observational components of the program. The related projects included various drifter studies and shipboard air-sea flux/meteorological measure-ments. We also occupied stations near mooring sites and along previous CTD lines, as well as providing ground-truth data for two airborne programs. Finally, the hydrographic data will be used in some of the numerical model studies associated with the ARI.

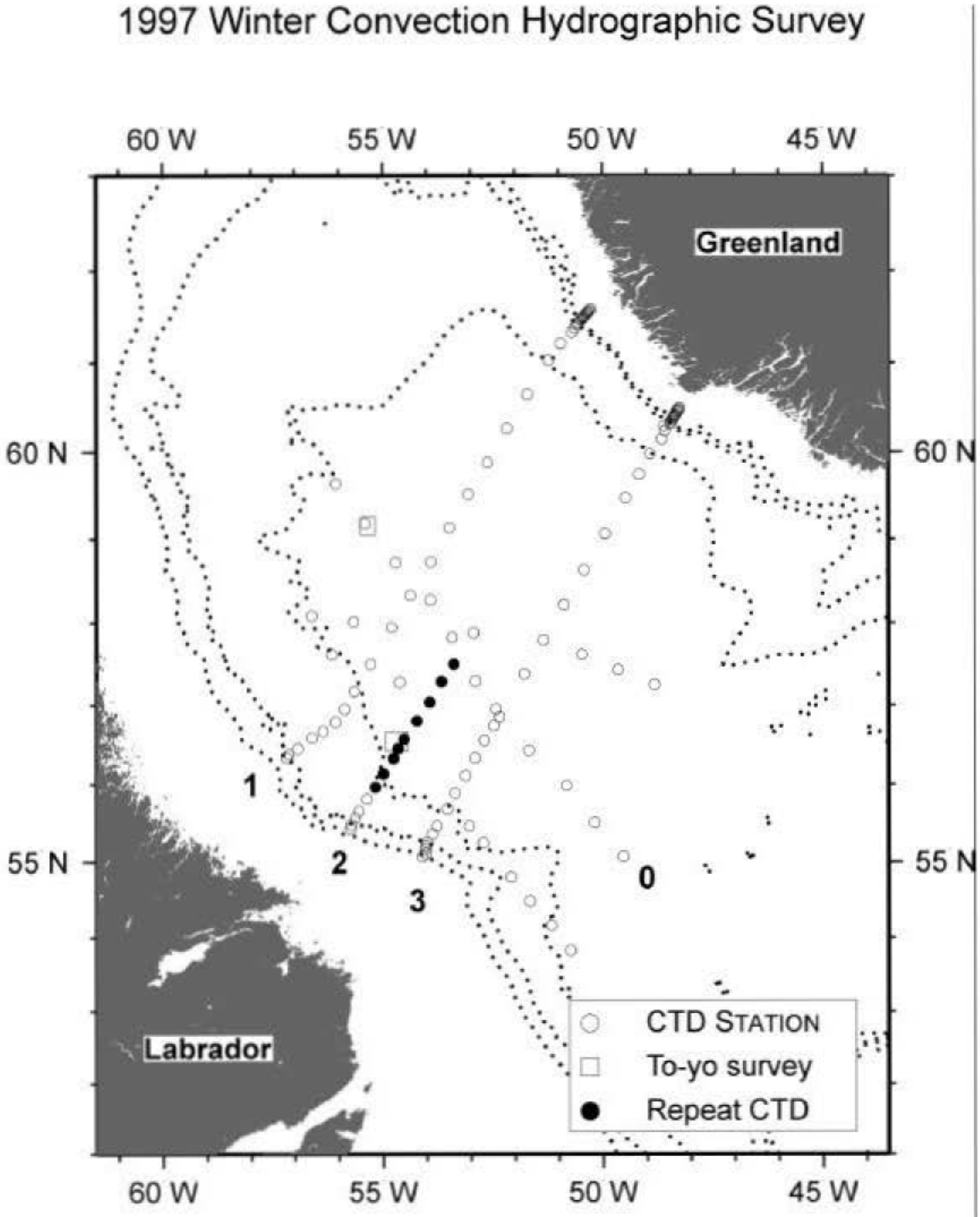

Figure 1: Station positions of cruise KNORR 147-V. Sections are labeled

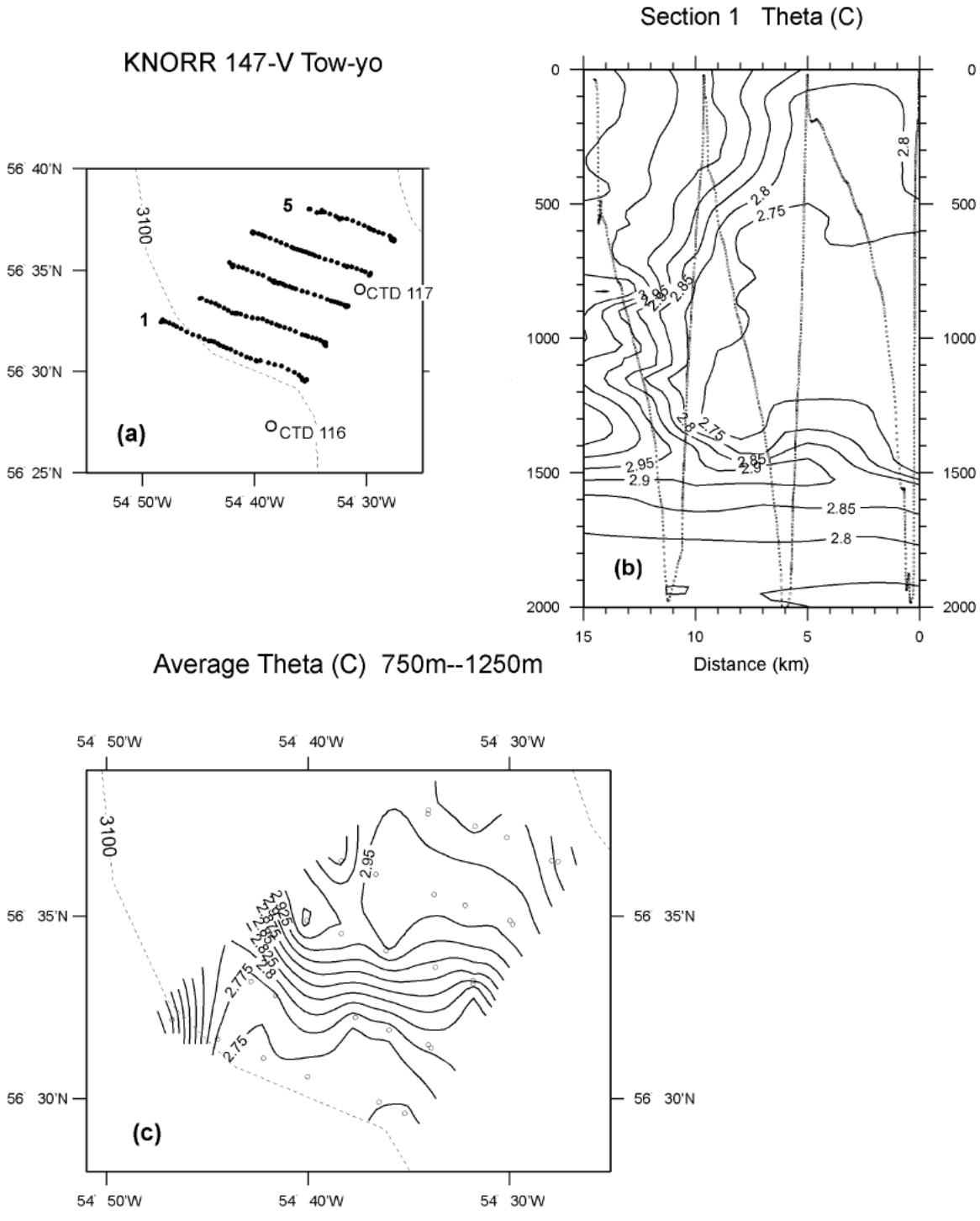

FIGURE 2: (A) SHIP TRACK OF TOW-YO. (B) VERTICAL VIEW ALONG